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⑤④ **Sheet material feeder.**

⑤⑦ Sheet 25 is fed from the bottom of a stack by a feed belt 38 and optimally additional feed belts 60. The edges of the resilient belt 38 overhang the edges of the supporting roller 36 and are overlapped by fixed guides 28 which restrain the advance of other sheets from the stack and cause bending or corrugating of the sheet 25 about an axis parallel to the direction of advance of the sheet, thereby separating the sheet 25 from other sheets and ensuring that a single sheet is fed.

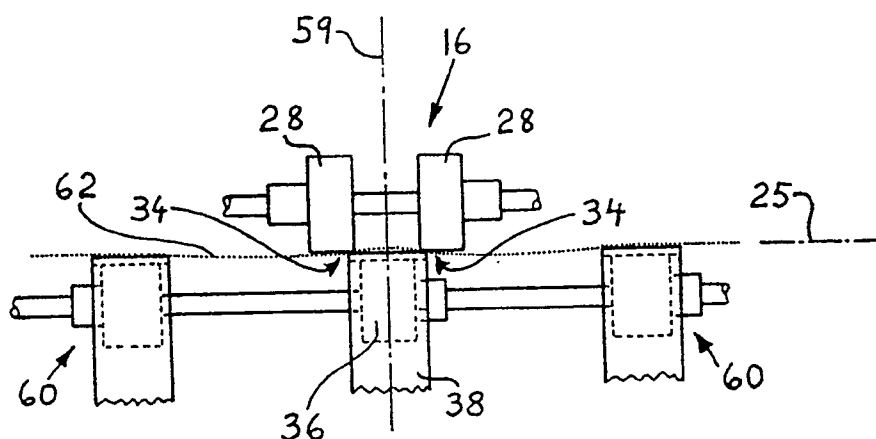


FIG.2

This invention relates generally to sheetfeeders, and more specifically to feeders which feed one article at a time from the bottom of a stack of sheet articles.

Sheet feeders which feed from the bottom of a stack often employ endless feed belts having a feeding surface contacting the bottom face of the lowermost sheet to thereby drive the sheet substantially in and along its plane from beneath the stack. Such sheet feeders commonly employ a restraining mechanism to prevent all but the lowermost sheet from being passed therethrough.

Difficulties encountered with conventional feeders have included misfeeds in the form of double or multiple sheets being fed or, alternately, the absence of a sheet when it should have been fed. These difficulties are experienced particularly in high speed operation and when sheet articles of differing properties are handled. For instance, different material thickness, stiffness, surface friction, and different sheet sizes have critically affected reliable operation of such feeders. Sensitive mechanical adjustment has been generally required for particular sheet properties and sizes to assure reliable operation, and even relatively slight changes in such properties and/or sizes necessitated readjustment of the device. Consequently, such feeders have also been unable reliably to handle a mix of sheets.

Prior art feeders for singulating and feeding individual sheets from the bottom of a stack have employed a variety of restrainer or retarder mechanisms to prevent all but the lowermost sheet to be fed. Such feeders are, for example, shown in the following U.S. Patents.

Rouan (U.S. Patent No. 2,273,288) discloses an adjustable separator for stripping letters from the bottom of a stack. Adjustment facilitates substantially constant tension whilst the separator yields as letters of varying thickness pass therebeneath. Kramell et al (U.S. Patent No. 3,895,791) discloses a bottom sheet feeder comprising a separation belt and a retard pad that is biased against the belt to bow the belt down. Strobel (U.S. Patent No. 3,934,869) shows a sheet separating and feeding apparatus including a feed belt adapted for frictional engagement with retard means 38. Generally similar devices are also shown by Godlewski and by Larson in U.S. Patent Nos. 4,666,140 and 4,555,103, respectively.

Imposition of transverse bowing onto sheet materials for various purposes during sheet handling and transporting is shown in prior art, for instance, by U.S. Patents No. 4,744,555 to Naramore et al, No. 4,663,527 to Koyama et al, and No. 2,157,228 to Bucicione et al.

The present invention is defined in the claims.

The sheet feeder of the present invention particularly obviates difficulties of the aforementioned kind and provides reliable singulating and feeding of sheet material from the bottom of a stack in high speed oper-

ation and for sheets that can vary significantly in properties as well as size. The instant sheet feeder tolerates substantial misalignments of individual sheets (including skew) without misfeeding and without the need for adjustments to accommodate different and mixed different sheet materials in uninterrupted operation. These characteristics provide significant operating and cost advantages not heretofore provided.

An important feature of one aspect of the invention is the provision of an improved sheet feeder and an improved method of singulating and feeding sheets of different and mixed properties and sizes from the bottom of a stack disposed in a hopper. The feeder includes means for urging sheets in the stack toward a singulating exit region and means for feeding a lowermost sheet from the stack through a restrainer device, wherein the restrainer device restrains all but the lowermost sheet from feeding out from the hopper by virtue of transversely, resiliently corrugating the lowermost sheet while it passes through the restrainer device.

In a first preferred embodiment, the restrainer device comprises a resilient member supported along a portion of an inner surface thereof on a support member and having an unsupported lateral overhang extending beyond the support member. Facing the outer surface of the resilient member in the region of the lateral overhang is an urging surface of a guide member. The spacing between the urging surface and the surface of the support member in a general direction normal to these surfaces is set to be the sum of the thickness of the resilient member between its inner and outer surfaces plus, at most, a distance that is less than the thickness of the thinnest sheet material operatively handled.

In operation, a lowermost sheet is fed from the stack between the outer surface of the resilient member and the urging surface to resiliently deflect the lateral overhang portion of the resilient member in order to pass through. As a result, at least a portion of the lowermost sheet is transversely, resiliently corrugated or bowed while passing through the restrainer device. Effects of this corrugation, particularly lifting effects on sheets overlaying the lowermost sheet and especially in leading edge regions of these sheets, assist and enhance restraining effects of the restraining device to reliably avoid misfeeds of sheets, even if sheets of different and mixed properties and sizes are fed.

In a second preferred embodiment, the restrainer device comprises two feed rollers. Each feed roller is disposed in juxtaposition to a guide member. The feed roller's outer periphery is spaced from the guide member by a gap that is preset to approximately correspond to (or to somewhat less than) the thickness of operatively-handled sheet material. The guide member's surface that is in juxtaposition to the feed roller's

periphery is tangent to a plane that is disposed beneath and parallel to the sheet feeding plane, the sheet feeding plane being defined as the plane of the lowermost sheet in the hopper stack. The resilient member is laterally spaced in relation to the feed rollers and has its upper, outer surface disposed approximately in the sheet-feeding plane.

In operation of this embodiment, a lowermost sheet is fed from the stack, being carried on the resilient member, and further through the gap between the feed roller and the guide member. As a result, at least a portion of the lowermost sheet is transversely, resiliently corrugated or bowed while passing through the restrainer device. Effects of this corrugation are as in the first embodiment.

The sheet feeder of the invention is particularly useful in feeding of paper sheets, such as individual paper sheets (plain or folded), signatures, envelopes, brochures, booklets, and the like. The feeder is also advantageous in the feeding of cards and card booklets, and cardboard, and it can handle still more rigid sheet materials, for instance plastic and metal sheets, and the like.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects, features and advantages of the invention will be apparent from the following more particular description of preferred embodiments of the invention, as illustrated in the accompanying drawings in which like reference numerals refer to like parts throughout different views. The drawings are schematic and not necessarily to scale, emphasis instead being placed upon illustrating principles of the invention:

FIG. 1 is a schematic side view of an embodiment of a sheet feeder according to principles of the present invention;

FIG. 2 is a schematic frontal view of a portion of the embodiment shown in FIG. 1;

FIG. 3 is a schematic sectioned enlargement of a fragmental portion of the view depicted in FIG. 2 showing further details;

FIG. 4 is a schematic side view showing a portion of a feeder in another embodiment of the invention;

FIG. 5 is a schematic side view showing a portion of a feeder in a further embodiment of the invention;

FIG. 5A is a schematic side view showing a portion of a feeder in a yet further embodiment of the invention;

FIG. 6 is a schematic side view showing detail aspects of a restrainer mounting according to the invention;

FIGS. 7 and 8 are schematic front views illustrating portions of yet further embodiments of the invention;

FIG. 9 is a schematic frontal view illustrating a further embodiment of the invention; and, FIG. 10 is a schematic side view of the embodiment illustrated in FIG. 9.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIG. 1, there is depicted a sheet feeder 10 comprising a hopper 12, a belt drive mechanism 14, a restraining mechanism 16, and a fragmentally-indicated mounting structure 18. Additionally shown here is a driven pair of nip rollers 20 for further transporting of sheets delivered thereto from feeder 10. Further defined here is a singulating plane 21 which is oriented substantially perpendicularly with respect to the bottom plane of hopper 12 and orthogonally to plane 25 of FIG. 1, which extends generally through the middle of restraining mechanism 16.

Hopper 12 holds a sheet stack 22 including a lowermost sheet 24. Sheet feeding plane 25 is indicated on the right side. A singulating exit region 23 is designated as the general sheet exit region (at the left side of hopper 12) about in the middle of the restraining mechanism 16 in the region of singulating plane 21. Lowermost sheet 24 is substantially disposed in sheet feeding plane 25. Disposed at the front end (left end) of hopper 12 is a barrier wall 26 and, further frontwardly, the restraining mechanism 16 comprising a stationary guide member 28 (here shown in form of a cylindrical body). Guide member 28 includes an urging surface 30 represented by a downwardly and rightwardly facing portion of the guide member's periphery. The rightwardly facing portion is designated as a first portion 32 and the downwardly facing portion is designated as a second portion 34.

Restraining mechanism 16 further comprises a support member 36 and a resilient member 38 supported thereon. Support member 36 and resilient member 38 are shown here in the form of a revolving pulley and an endless belt, respectively -- both also comprised in belt drive mechanism 14.

Belt drive mechanism 14 further includes a plurality of pulleys carrying resilient member 38 in the form of an endless flat belt. At least one of the pulleys is motor-driven so that resilient member 38 moves in the direction of arrow 40. Also comprised in belt drive mechanism 14 is an adjustable idler roller 42 that is borne freely revolvably upon an eccentrically mounted boss. Roller 42 can be adjusted to lift or lower the thereupon carried portion of the endless belt by angular adjustment of the eccentric boss.

As shown in FIGS. 2 and 3, at least one guide member 28 is disposed laterally in a position so as to slightly overlap resilient member 38 in a region of a lateral overhang thereof over support member 36. FIG. 3 represents an enlarged portion of a section

substantially through singulating plane 21.

Referring now more particularly to FIGS. 2 and 3, support member 36 includes a support surface 44 that has a supporting edge region 46 at least on one side thereof for supporting resilient member 38. Resilient member 38 has an outer surface 48 and an inner surface 50. Inner surface 50 contacts support surface 44 at least in a supporting edge region 46. Resilient member 38 overhangs laterally over the side of support member 36 by a lateral overhang 52. Second portion 34 of urging surface 30 (of guide member 28) has an urging edge region 54 on one side thereof. In urging edge region 54, second portion 34 of urging surface 30 faces outer surface 48, thusly forming an overlap 56 over a portion of the lateral overhang 52 of resilient member 38.

Also indicated in FIG. 3 is a portion of a sheet 58 as it is being fed between guide member 28 and resilient member 38 through restraining mechanism 16.

Particularly with reference to FIG. 2, a pair of guide members 28 is shown, each guide member being disposed symmetrically on lateral sides of resilient member 38 in mirror-image manner mirrored with respect to a center plane 59. Additional belt drive means 60 supports sheets fed by the feeder. It should be noted that additional belt drive means 60 can be replaced by low-friction stationary guide surfaces for lateral support of fed sheets. A typical sheet 62, fed between guide members 28 and resilient member 38, is indicated by a dotted line. It will be appreciated, also in view of FIG. 3, that sheets are slightly-transversely, resiliently corrugated, bowed, or waved slightly out of the sheet feeding plane 25 while being fed through restraining mechanism 16, as indicated here by typical sheet 62.

As illustrated in FIGS. 1-3, resilient member 38 can be a plain endless flat belt or a flat timing belt having teeth along its inner surface to engage corresponding grooves or teeth in the periphery of the belt-carrying pulleys. Conventional belts having appropriate resiliently elastic properties have been found adequate for purposes of this invention. Although it has been found that particular surface properties of guide member 28 in its urging surface 30 have little, if any, influence on proper operation of the feeder, a preferred material for surface 30 is polyurethane of 83 Shore A Durometer hardness.

In operation of a sheet material feeder as particularly depicted in FIGS. 1 and 2, sheet stack 22 is urged toward singulating plane 21 by the feeding motion of resilient member 38 (being a driven endless belt) upon which stack 22 is at least partially supported in hopper 22. Leading edges of all sheets but the lowermost sheet 24 impact on barrier wall 26 or on guide member 28 and are stopped thereby. The lowermost sheet 24 continues to be fed by resilient member 38 into the singulating exit region 23 between guide member 28 and resilient member 38. As lowermost

sheet 24 is nipped therebetween, it is slightly-transversely, resiliently corrugated at least in the region of singulating exit region 23 by virtue of the structural relationships between members 28 and 38 (as particularly illustrated in FIG. 3). Hence, the next one or two or more sheets in the stack have their leading ends slightly lifted up. Moreover, the lowermost sheet is partially separated by the corrugation from the next sheet, which results in a significant reduction of friction therebetween. These effects reliably enhance the operation by avoidance of multiple sheet misfeeds.

The corrugated sheet is now delivered to further equipment, for instance via nip rollers 20. A thusly-delivered sheet can be sensed in order to temporarily stop belt drive mechanism 14 until the delivered sheet has passed on some desired distance, when the belt drive mechanism is again energized to feed the next sheet. Spacing between successively delivered sheets can be thusly changed as desired.

The sheet corrugating operation can be best appreciated in view of FIG. 3. As a lowermost sheet is fed from the bottom of sheet stack 22 upon resilient member 38, the leading edge of the sheet is forced under guide member 28 and the sheet slides therealong while it is fed. The spacing provided between supporting edge region 46 (of support member 36) and urging-edge region 54 (of guide member 28) is such that a sheet fed upon resilient member 38 resiliently deflects lateral overhang 52 while the sheet is slightly squeezed or nipped in the region of overlap 56 between urging-edge region 54 and the portion of the outer surface 48 (of resilient member 38) disposed in a deflected portion of lateral overhang 52.

In this respect, there is defined: a first plane 63 that is substantially parallel to sheet feeding plane 25 and that is tangent to urging surface 30 in the region of singulating plane 21; and, a second plane 65 that is parallel to first plane 63 and that is tangent to the support surface 44 at least in the supporting edge region 46 in the region of singulating plane 21. These first and second planes are preferably spaced apart by a distance that is less than the sum of the thickness of the resilient member 38 plus the smallest thickness of sheet material that is to be operatively moved through the singulator region.

For example, a gap of about one thousandth of an inch between the outer surface 48 (of a relaxed resilient member 38 in absence of a sheet) facilitates reliable feeding and singulating of sheets with thicknesses in the approximate range of about .002 to .018 inches and thicker without readjustment. This gap can be further reduced to become an interference; for instance, an interference (negative gap) of .010 inches will still provide for reliable feeding of sheets in the aforementioned thicknesses. Such an interference has been found advantageous, but not essential, when sheet material of particularly unusual or troublesome surface characteristics is used.

In respect to larger sheet material thicknesses, for instance those considerably in excess of .018 inches, it has been found that a gap of .010 inches reliably handles most customary sheet materials. A preferred length for overhang 52 to handle most customary sheet materials is in the range of about 1/8 of an inch or more, and not substantially less than about 1/16 of an inch. It will be appreciated that overlap 56 is always less than overhang 52. A preferred length for lateral overlap 56, also to handle most customary sheet materials, is about 1/16 of an inch or more. Moreover, reliable handling of sheet materials in thicknesses approaching 1/4 of an inch, for instance as given by coupon books and the like, is facilitated by the sheet material feeder according to the principles of the invention by appropriate gap adjustment and by provision of a correspondingly longer lateral overhang 52.

Hopper 12, shown in FIG. 1, need not be oriented horizontally but can be tilted downwardly toward singulating plane 21 (from right to left). It has been found that a tilt of up to about 30 degrees does not significantly affect operation. Moreover, operation at a greater tilt is feasible by appropriate adjustments of structural component relationships.

In respect to the shape of urging surface 30 in transverse direction, it should be noted that other than planar shapes can be employed, such as for instance convex, concave, stepped or undercut, grooved, and the like. Similarly, support surface 44 can be in a variety of shapes. In this respect, for instance when support member 36 is a pulley, it can have a cylindrical shape, a crowned, barrel shape, and the like.

In regard to the relative locations of guide member 28 and support member 36, whereas FIG. 1 illustrates these two components one above the other generally disposed in singulating plane 21, guide member 28 (together with barrier wall 26) can be located some small distance upstream so that it is no longer disposed directly above the center line of support member 36.

Referring now to FIG. 4, another embodiment of the invention is illustrated here by the portion that differs from the embodiment depicted in FIGS. 1 and 2. In particular, a restraining mechanism 66 is provided comprising guide member 28 (the same or similar as shown in FIGS. 1-3) and a resilient member 68 in form of a sleeve borne about the periphery of a support member 76, wherein support member 76 is a driven roller. Support member 76 is substantially similar to support member 36 of FIGS. 1-3. The portion of a belt drive mechanism 78 disposed in the vicinity of support member 76 is shown here to include a revolving pulley 80 and an endless flat belt 82 that is driven in the direction of arrow 83. When viewed in conjunction with FIG. 1, it will be apparent that belt drive mechanism 78 differs only insignificantly from belt drive mechanism 14 (FIG. 1).

In particular, belt drive mechanism 78 now extends leftwardly for a shorter distance and does not include a portion of restraining mechanism 66 (16 in FIG. 1). Sheets are fed (substantially in sheet feeding plane 25) from the hopper upon the top of endless flat belt 82 to and through the nip between resilient member 68 and guide member 28. Support member 76 is driven to provide the same outer surface speed for belt 82 and resilient member 68.

With respect to further details of structure and operation, the embodiment indicated in FIG. 4 is similar or identical to the embodiment illustrated in and described in conjunction with FIGS. 1-3. Particularly also FIG. 3 and the description presented therewith is equally applicable.

Referring now to FIG. 5, a further embodiment of the invention is illustrated here by the portion that differs from the embodiment depicted in FIGS. 1 and 2. In particular, a restraining mechanism 86 is provided comprising guide member 28 (the same or similar as shown in FIGS. 1-3) and resilient member 38 substantially the same as in FIGS. 1-3. The only significantly different component being a support member 88 in form of a stationary slide block adapted to facilitate sliding thereover of resilient member 38 in the driven direction indicated by arrow 40. The slide block of support member 88 is made preferably of a low friction material, such as for instance given by Delrin, Teflon, and the like, but can be made of other materials too. Support member 88 in sectional view of its upper portion (together with guide member 28 and resilient member 38) is substantially identical to support member 36 in the depiction in FIG. 3, and the description presented in conjunction therewith is equally applicable.

Referring now to FIG. 5A, a further embodiment is illustrated in regard to aspects differing from those shown in FIG. 5. A restraining mechanism 89 is provided comprising guide member 28, support member 89A, and resilient member 89C (in the form of an endless belt). Resilient member 89C is carried by pulley 89B (and at least one other pulley not shown here) and is driven in the direction of arrow 40. Support member 89A is provided in the form of a stationary slide block adapted to facilitate sliding thereover of resilient member 89C. In all other respects and in function, restraining mechanism 89 is similar or identical to the mechanism shown in FIG. 5, and the description given in conjunction therewith is equally applicable.

With respect to further details of structure and operation, the embodiments indicated in FIGS. 5 and 5A are similar or identical to the embodiment illustrated in and described in conjunction with FIGS. 1-3.

Referring now to FIG. 6, a mounting arrangement 90 for mounting guide member 28 to mounting structure 18 of a sheet feeder according to the invention includes a bracket 92, means for adjusting the vertical

position of guide member 28, and means for spring-loading guide member 28 downwardly. As indicated, the arrangement is disposed generally in singulating plane 21 having the lowermost portion of guide member 28 disposed in the general proximity of sheet feeding plane 25. Bracket 92 is rigidly mounted to structure 18 (and can be also or alternately attached to barrier wall 26) by conventional means not shown.

A boss 94 having an adjustment knob 95 extends vertically adjustably (for instance screw-threadedly) through a hole in bracket 92. A block 96 is borne on boss 94 vertically slideably and is irrotationally guided. A stop collar 97 is affixed to the lower end of boss 94. A compression spring 98 is threaded over boss 94 and extends between bracket 92 and block 96 in preloaded manner so that block 96 is forced downwardly against stop collar 97. Guide member 28 is attached to block 96. The vertical position of block 96 and therewith of guide member 28 can be adjusted, for instance, by turning of knob 95.

It will be apparent that guide member 28 can move upwardly from an adjusted position against the spring-loading of spring 98. This latter effect is utilized, for example, when a thick sheet material article is fed beneath guide member 28 such that the resilient elastic properties of resilient member 38 in the arrangements of the restraining mechanism for instance (as shown in FIGS. 1-5) are inadequate to provide commensurate resilient give. It has been found, however, that spring-loading by spring 98 is not required for proper normal operation of the feeder when the properties of fed sheet materials (for instance thicknesses) do not grossly vary during a particular run. Therefore, in such an embodiment, spring 98 is omitted and guide member 28 is adjusted by adjustment means (knob 95, boss 94) to a substantially fixed position to suit a relatively wide range of particular sheet thicknesses handled.

In respect to the particular mounting arrangement and adjusting means (for guide member 28) shown here by example, it should be understood that other suitable conventional devices can be employed to function equally well. For instance, guide member 28 can be mounted in an angularly-adjustable cantilever mechanism.

Referring now to FIGS. 7 and 8, two further examples of slightly differing embodiments to the ones discussed hereinbefore are illustrated. The differences will be appreciated particularly also in view of the depiction in FIG. 2.

FIG. 7 includes two support members 36 (each carrying a resilient member 38) and each of the two guide members 28 overlap the respective resilient member at a laterally-opposite side. The arrangement is substantially symmetrical again about center plane 59. In other respects this arrangement is substantially identical to the embodiment depicted in FIG. 2. Particularly also FIG. 3 and the description given in con-

junction therewith is similarly applicable to the embodiment of FIG. 7.

FIG. 8 also includes two support members 36 (each carrying a resilient member 38) and each of the two guide members 28 overlap the respective resilient member at a laterally opposite side (albeit different sides to the ones of FIG. 7). The arrangement is substantially symmetrical again about center plane 59. In other respects this arrangement is also substantially identical to the embodiment depicted in FIG. 2. Particularly also FIG. 3 and the description given in conjunction therewith is similarly also applicable to the embodiment of FIG. 8.

Although the depictions of FIGS. 7 and 8 show symmetrical arrangements (with respect to center line 59) of preferred embodiments, it should be understood that the arrangements' symmetry is adopted here for the sake of convenience, rather than to imply a structural limitation. It will be appreciated that an appropriate asymmetrical layout of the components can function equally well.

As the foregoing descriptions in conjunction with FIGS. 1-6 are applicable also to the depictions of FIGS. 7-8, no further discussion is offered here with respect to the latter.

A further embodiment of the invention is illustrated in FIGS. 9 and 10 and includes a restrainer mechanism 100 that is here employed instead of the restraining mechanism 16 of FIG. 1. For clarification purposes, the singulating plane 21 of FIG. 1 is also indicated in FIG. 10 to assist in locating the restrainer mechanism 100 in relation to the illustration of the feeder 10 in FIG. 1. The region at and vicinal to the singulating plane 21 is designated as exit region 102 in FIG. 10.

A sheet-feeding plane 101 is defined as the plane in which the lowermost sheet is disposed at the bottom of the sheet stack (lowermost sheet 24, sheet stack 22 - FIG. 1) and in which the lowermost sheet is generally fed to and through exit region 102. Sheet feeding plane 101 is shown in dot-dash representation in FIGS. 9 and 10.

Restrainer mechanism 100 comprises feed rollers 104, guide members 106, and resilient members 108 and 108'. Feed rollers 104 are borne on a common shaft 110 and are driven thereby in direction of arrow 112 by means not shown. Feed rollers 104 can be provided with an elastically-resilient periphery, for instance by having at least an annular cylindrical peripheral portion of polyurethane material or of a similar elastomer.

Guide members 106 are shown in form of cylindrical bodies. Although the guide members could be revolvable, they are stationary for purposes of a preferred mode of operation. Hence as shown here, guide members 106 are mounted upon a common shaft 114 which is attached to a mounting block 117 that, in turn, is mounted in the framework of the feeder

(not shown here). Guide members 106 include along their peripheries a first surface portion 116 (FIG. 10) which approximately faces leading edges of particularly the lower sheets of the stack in the hopper (located to the left in FIG. 10).

Guide members 106 also include a second-surface portions 118 substantially disposed in the region of juxtaposition with respect to feed rollers 104. Second-surface portion 118 can be provided with elastically resilient properties, for instance by employment of polyurethane material or a similar elastomer for this portion of the guide members. In general, for practical reasons, the entire periphery of the guide members 106 can be advantageously made of elastomeric material. Elastically resilient characteristics of guide members 106 are advantageous, but not essential, to proper operation of the restraining mechanism, unless extreme ranges of mixed sheet material thicknesses and/or of other properties are to be handled.

Guide members 106 are disposed with respect to sheet feeding plane 101 such that second-surface portions 118 are substantially tangent to a plane that is disposed substantially beneath and parallel with respect to the sheet feeding plane 101. Hence also the upper peripheries of feed rollers 104 (that are juxtaposed to second-surface portions 118) are disposed substantially beneath and parallel with respect to the sheet feeding plane 101. As indicated hereinbefore, guide members 106 are stationary in a preferred mode of operation. Consequently, the shape of their peripheral surfaces need not be cylindrical except that their first and second surface portions 116 and 118 should be smooth and generally convex.

A roller/guide gap 120 is defined as the spacing between the second surface portion 118 and the upper periphery of feed roller 104. This gap 120 is set to a spacing that is equal to or less than the range of sheet material thicknesses that is to be operatively handled by the feeder device in a particular run or batch.

Resilient members 108 and 108' are shown in form of endless belts, as preferably used therefor. At least the one resilient member 108 is necessary for proper operation according to the invention. Resilient members 108' are provided as helper belts to assist in handling of laterally-wider sheet material; to provide for additional transverse corrugations (bends) in the sheet material; and, to reduce excessive bowing of lateral sides of sheets (out of the sheet feeding plane). Any one or all of resilient members 108 and 108' can be driven in the direction of arrow 122. The belts can also be free-running. In the situation of driven belts, the belts are operative as feeder belts and, therefore, are driven substantially at the same speed as the peripheries of the feed rollers 104. As indicated, resilient members 108 (and 108') can be supported by pulleys 124 and additional suitable pulleys not shown

here. It should be noted that, for clarity's sake, resilient member 108 is shown sectioned in FIG. 9 (to show pulley 124). Pulleys bearing resilient members 108' are not shown here.

At least a portion of the upper surfaces of resilient members 108 and 108' are disposed substantially in sheet feeding plane 101 (at least in exit region 102). FIG. 9 also shows in dashed line representation a sheet 128 as it is being fed through the restrainer mechanism 100.

FIG. 9 illustrates also preferred lateral relationships between key features of this embodiment. Resilient member 108 is disposed approximately along the middle region of sheet material (in direction of feed thereof). Guide members 106 and feed rollers 104 are approximately symmetrically, laterally spaced from and disposed on either side of resilient member 108. Resilient members 108' (helper belts) are further approximately symmetrically laterally spaced from respectively adjacent guide members 106 and feed rollers 104.

As a result of the lateral spacings together with the vertical relationships of resilient members 108 and 108' with respect to guide members 106 (and feed rollers 104), sheet 128 is transversely corrugated or bowed while it is being fed through exit region 102, as indicated in FIG. 9. It will be apparent from this illustration that different transversely spaced portions of sheet 128 are engaged and are fed along guide members 106 (and by feed rollers 104) and upon and along resilient members 108 and 108'.

In operation of the embodiment of the invention described in conjunction with FIGS. 9 and 10 (and partly referring back to portions of the illustration in FIG. 1), a stack of hopper-held sheets is urged in direction of arrow 122 toward the singulating plane 21 (also see FIG. 1) and therewith also toward exit region 102 either by urging means (not shown) or by means of the endless belts of restraining members 108 and 108' (or by cooperative effect thereof). Leading edges of at least the lower sheets of the stack except for the leading edges of the lowermost sheet impact on first surface portion 116 of guide members 106 and are stopped thereby from moving further. The lowermost sheet continues to be fed to and through exit region 102 along second surface portion 118 and therebetween and feed rollers 104 through roller/guide gap 120.

As indicated in FIG. 9, lowermost sheet 128 is engaged at different transverse positions by second surface portions 118 of guide members 106 and by upper surfaces of resilient members 108 and 108'. That is, second surface portions 118 are disposed in a plane that is parallel to and beneath the sheet feeding plane 101, whereas upper surfaces of resilient members 108 and 108' are disposed substantially in the sheet feeding plane 101. The lowermost sheet 128 is thereby transversely elastically corrugated or

bowed in a transverse wave-like manner as illustrated in FIG. 9. This corrugating or bowing occurs in the exit region 102 and extends at least some distance upstream. Hence, the next one or two or more sheets in the stack have their leading ends slightly lifted up. This effect enhances separation of the lowermost sheet from the next sheet and supports stoppage of the next sheet at its leading edge by the first surface portion 116, as long as at least a portion of the lowermost sheet (being corrugated) supports this next sheet. Moreover, because the lowermost sheet is partially separated by its corrugation from the next sheet, significant reduction of friction effects result thereby between the lowermost sheet and the next sheet. Hence, the lowermost sheet can easier slide from beneath the next sheet without dragging the next sheet along. These effects enhance reliable operation and avoid multiple sheet misfeeds.

The lowermost sheet 128 is then delivered to further equipment, for instance by and upon resilient members 108 and/or 108' or by other conventional conveying means, not shown.

While the invention has been particularly shown and described with reference to preferred embodiments thereof, it will be understood by those skilled in the art that various changes and modifications in form and details may be made therein without departing from the spirit and scope of the invention.

Claims

1. A sheet material feeder (10) for seriatim feeding of lowermost sheets (24, 128) from a sheet stack, said sheet material feeder comprising:
 - a sheet hopper (12) for holding a stack of sheets (22), said sheet hopper (12) having a singulating exit region (23, 102) and feeding means (14) for urging a lowermost sheet (24, 128) toward said singulating exit region (23, 102);
 - a sheet feeding plane (25, 101) in which said lowermost sheet (24, 128) of said sheet stack (22) is substantially disposed while being fed from said sheet stack (22);
 - restraining means (16, 100) for restraining all but the lowermost sheet (24, 128) of said sheet stack (22) from feeding through said exit region (23, 102), said restraining means including:
 - first and second surface means (32, 116 AND 34, 118), said second surface means facing at least a portion of said feeding means (14) in said exit region (23, 102) and forming a gap therebetween and said first surface means (32, 116) facing toward the leading edges of sheets (22) of said stack of sheets;
 - support means (36, 124);
 - at least one resilient member (38, 108) supported by said support means (36, 124);

said feeding means (14) being operative to feed said lowermost sheet through said gap; and, said resilient means (38, 108) and said second surface being mutually cooperative to bend said lowermost sheet (24, 128) relative to said sheet feeding plane as said lowermost sheet (24, 128) passes through said gap to thereby corrugate said lowermost sheet as it passes through said exit region (23, 102).

2. The apparatus of claim 1 wherein said resilient member is wider than said support member to thereby have a lateral overhang portion thereof extending beyond the width of said support member.
3. The apparatus of claim 2 wherein said second surface means is located adjacent said lateral overhang portion and spaced therefrom so that passage of said lowermost sheet through said gap causes said lowermost sheet and said lateral overhang to bend and result in said corrugation of said lowermost sheet.
4. A sheet material feeder (10) for seriatim feeding of lowermost sheets (24) from a sheet stack (22), said sheet material feeder comprising:
 - a sheet hopper (12) for holding a stack of sheets (22), said sheet hopper (12) having a singulating exit region (23) and means (14) for urging sheets (24) toward said singulating exit region (23);
 - a sheet feeding plane (25) in which said lowermost sheet (24) of the sheet stack (22) is substantially disposed while being fed from the sheet stack (22);
 - a singulating plane (21) through said singulating exit region (23) and oriented substantially orthogonally to the direction in which said lowermost sheet (24) is fed from the sheet stack (22);
 - means for feeding said lowermost sheets (24) from said sheet hopper (12) through said singulating plane (21);
 - first and second restraining means (16) for restraining all but the lowermost sheet (24) of the sheet stack (22) from feeding through said singulating plane (21);
 - said first restraining means including a guide member (28), said guide member (28) including an urging surface (30) having an urging edge region on one side thereof;
 - said urging surface (30) including a first (32) and a second (34) portion, said first portion (32) generally facing toward leading edges of lower sheets (24) in the sheet stack (22);
 - said second restraining means (34) including a support member (36) and a resilient member (38) supported thereon, said support member

(36) including a support surface (44) having a supporting edge region (46) on one side thereof and supporting said resilient member (38);

said resilient member (38) having an outer (48) and an inner (50) surface and a thickness therebetween, said inner surface (50) including a contact-surface region substantially contacting said support surface (44);

said resilient member (38) including a lateral overhang (56) extending laterally beyond said supporting edge region (46), wherein said second portion (34) of said urging surface faces said outer surface (48) in the region of said lateral overhang (56);

a first plane (63) substantially parallel to said sheet feeding plane (25); and,

a second plane (65) parallel to said first plane (63);

wherein said first and second planes (63, 65) are spaced apart by a distance that is less than the sum of said thickness of said resilient member plus the smallest thickness of sheet material (24) operatively handled by said sheet material feeder (10), and wherein said lowermost sheets (24) are fed through said singulating plane between said urging edge region (54) and said outer surface (48).

5. A sheet material feeder (10) for seriatim feeding of lowermost sheets (128) from a sheet stack (22), said sheet material feeder comprising:

a sheet hopper (12) for holding a stack of sheets (22), said sheet hopper having an exit region (102) and means (14) for urging sheets toward said exit region, the position and orientation of the lowermost sheet (128) in said stack of sheets defining a sheet feeding plane (101);

means for feeding the lowermost sheet (128) of said stack of sheets (22) to said exit region (102) substantially along said sheet-feeding plane (101); and,

restraining means (100) for restraining all but the lowermost sheet (128) of said stack of sheets (22) from being fed through said exit region (102), said restraining means (100) being disposed substantially in said exit region (102) and including:

at least two feed rollers (104 - FIG. 10) for feeding the lowermost sheet (128) through said exit region (102), said feed rollers (104) being transversely spaced with respect to one another,

at least two guide members (106) each including a first (116) and a second (118) surface portion, said first surface portion (116) generally facing toward leading edges of lower sheets of said stack of sheets (22) and said second surface portion (118) including a periphery

that is spaced from said sheet feeding plane (101), said periphery facing toward the periphery of one of said at least two feed rollers (106) and spaced therefrom to define a gap (120), said feed rollers being operative in feeding thereupon the lowermost sheet (128) adjacent said second surface portions (118);

at least one resilient member (108) laterally spaced from said guide members (106) for carrying the lowermost sheet (128) through said exit region (102);

whereby the lowermost sheet is transversely resiliently corrugated between transverse portions thereof with respect to said sheet feeding plane between said at least one resilient member and said at least two feed rollers and guide members while the lowermost sheet is being fed through said exit region.

6. The apparatus of any one of claims 1 through 5 wherein said first and second surface means are stationary.
7. The apparatus of any one of claims 1-6 wherein said resilient member is an endless belt.
8. A method of seriatim feeding of lowermost sheets from a stack of sheets in a sheet feeder of the type in which a support member has a resilient member mounted thereon so that an overhang portion of said resilient member overhangs the width of said support member and an urging means is located adjacent said overhang portion to form a gap therebetween that is offset from a sheet feeding plane at least when a sheet is moved between said urging means and said overhang portion, said method comprising the steps of:
 - locating the lowermost sheet of said stack in a sheet-feeding plane which extends through a singulating exit region and restraining all but the lowermost sheet of said sheet stack from feeding through said singulating exit region;
 - feeding said lowermost sheet from said hopper in said sheet feeding plane to move said lowermost sheet toward said singulating exit region and through said gap between said urging means and said overhang portion;
 - Corrugating said lower sheet as a transverse portion of said sheet is fed through such offset gap and partly out of said sheet feeding plane while being moved through said singulating exit region.
9. A method of seriatim feeding of lowermost sheets from a sheet stack (22) disposed in a hopper (12) having an exit region (102), the position and orientation of the lowermost sheet (128) in said sheet stack (22) defining a sheet feeding plane

(101), the method comprising the steps of:

urging said sheets (128) toward said exit region (102);

feeding the lowermost sheet (128) to said exit region (102);

restraining all but the lowermost sheet from being fed through said exit region, said step of restraining including:

feeding the lowermost sheet along first and second transverse portions thereof through said exit region substantially parallel to said sheet feeding plane (101) between at least two feed rollers (104) and at least two guide members (106), respectively;

carrying further transverse portions of the lowermost sheet (128) through said exit region (102) substantially in said sheet feeding plane (101) upon at least one resilient member (108) that is laterally spaced from said guide members (106); and,

resiliently corrugating at least a portion of the lowermost sheet (128) transversely to the direction of lowermost sheet feeding at least in said exit region (102).

- 10.** Apparatus for feeding sheet material from a sheet material stack (22), the apparatus comprising receiving means (12) for receiving the stack, urging means (14) for advancing the lowermost sheet from the stack, and bending means (28, 36, 38) for cooperating with the lowermost sheet to form a corrugation or wave or bow in the sheet as it is drawn from the stack, in order to facilitate separation of the lowermost sheet from the next sheet in the stack.

- 11.** Apparatus according to claim 10, wherein the bending means comprises a pair of guides (28) to engage one side of the sheet (24), the guides of the pair being spaced apart in a direction transverse to the direction of advance of the sheet, and a co-operating member or members (36, 38) to engage the other side of the sheet in the zone between the guides.

- 12.** A method for feeding sheet material from a sheet material stack, the method comprising advancing the lowermost sheet of the stack, and bending the lowermost sheet as it is drawn from the stack to form a corrugation or wave or bow in the sheet, in order to facilitate separation of the lowermost sheet from the next sheet in the stack.

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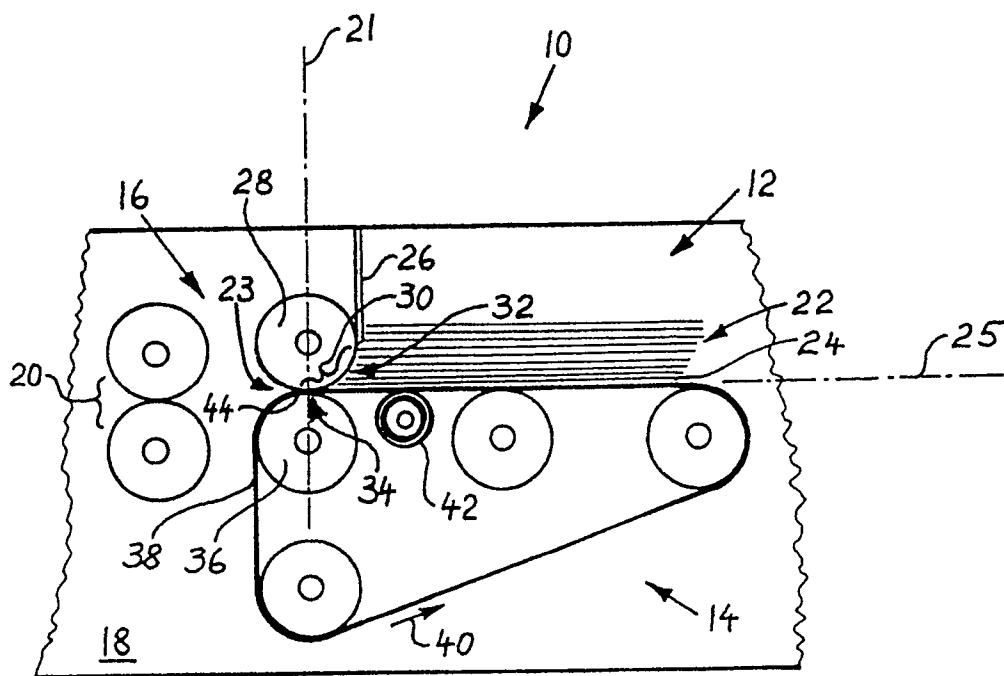


FIG.1

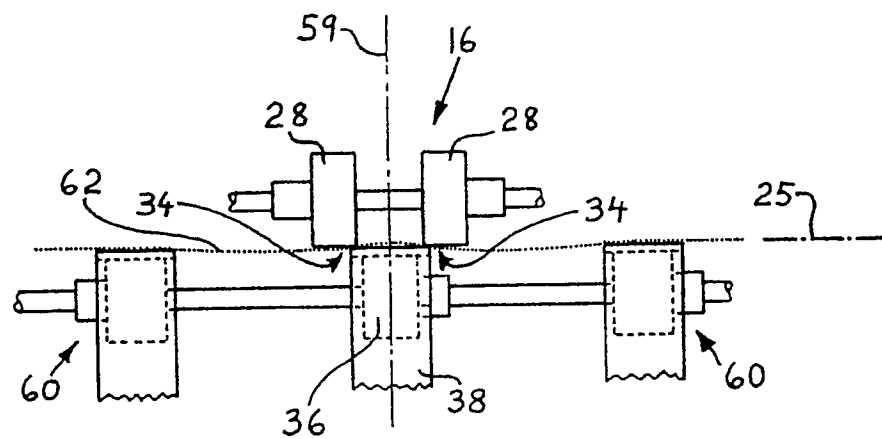


FIG.2

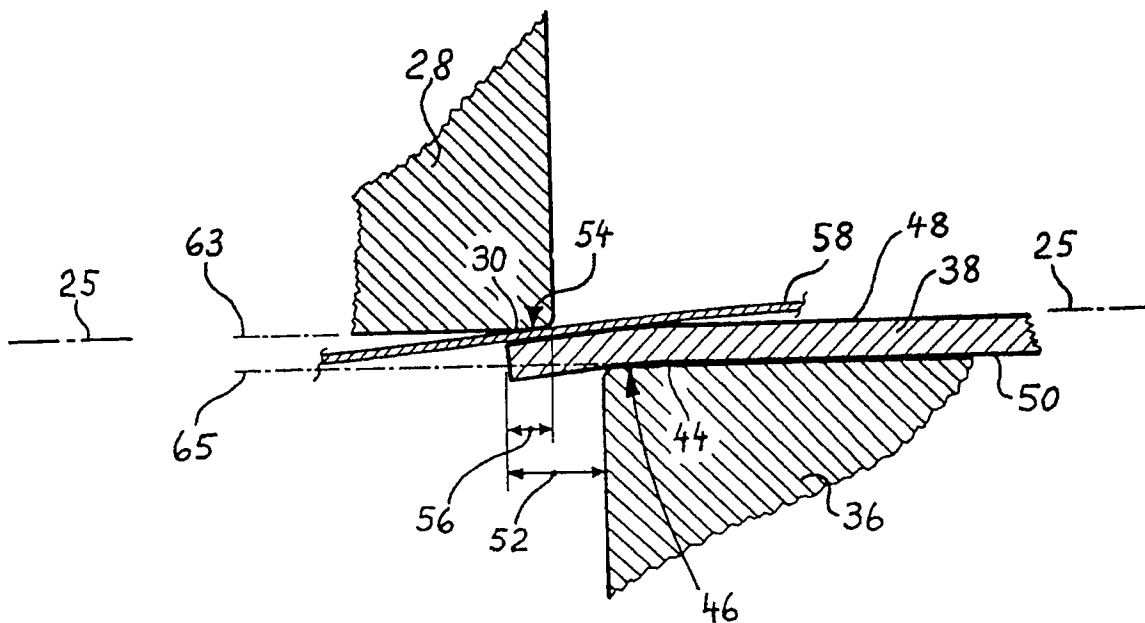


FIG. 3

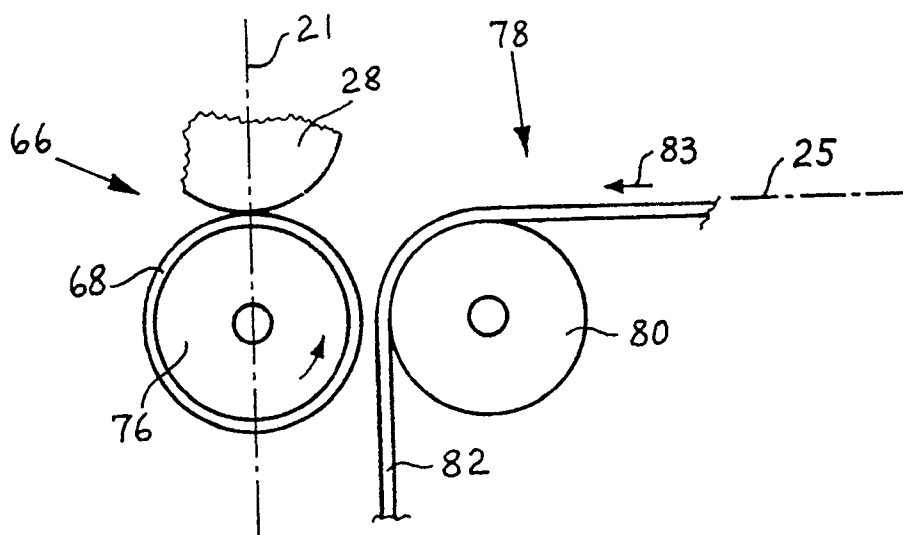


FIG. 4

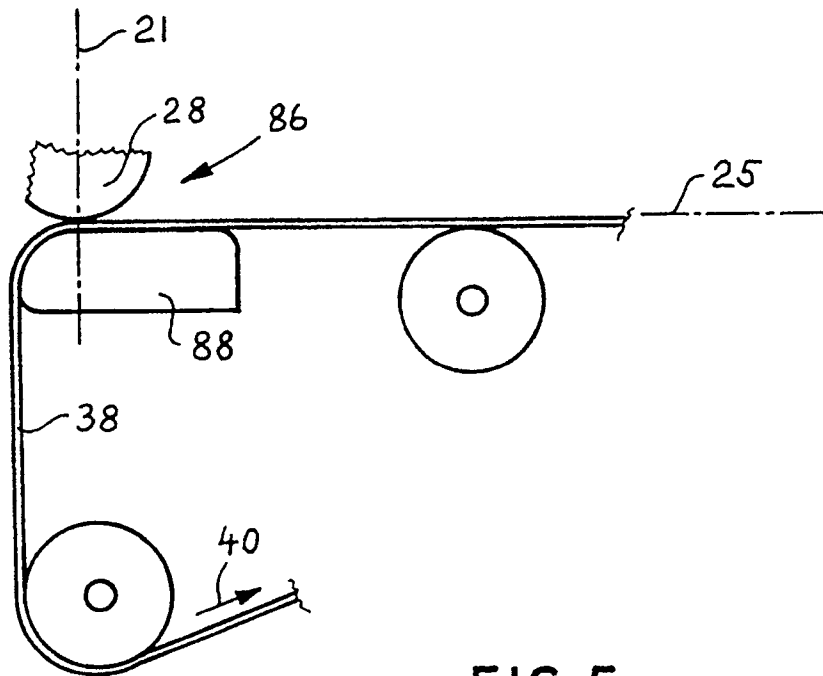


FIG. 5

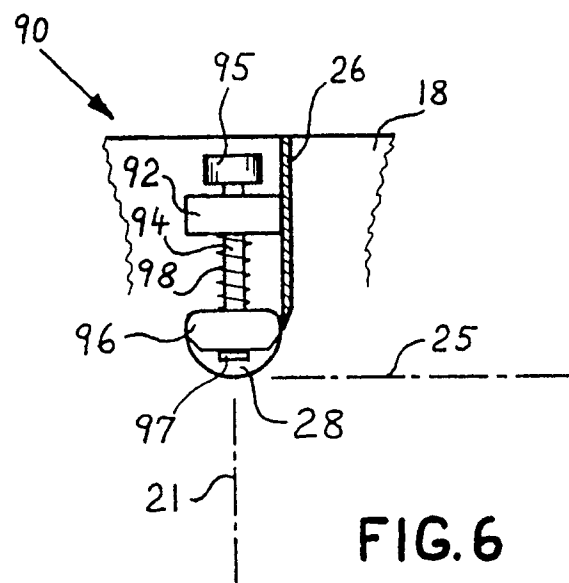


FIG. 6

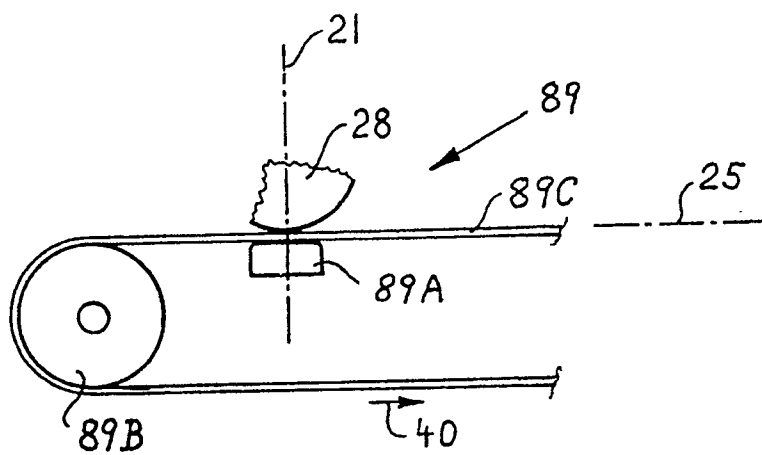


FIG. 5A

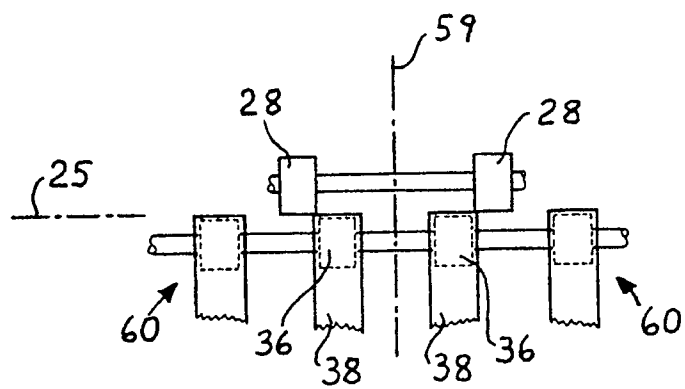


FIG. 7

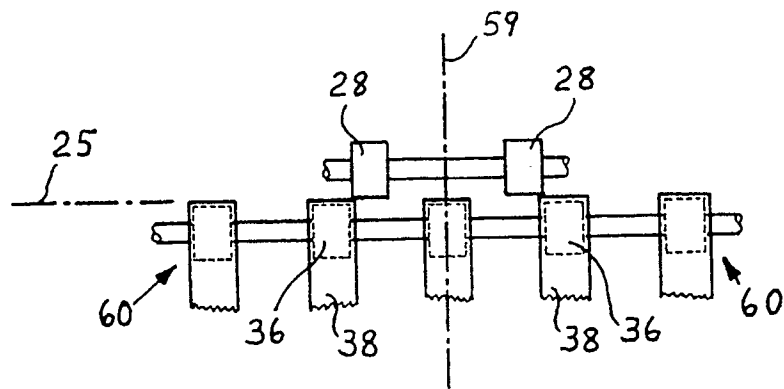
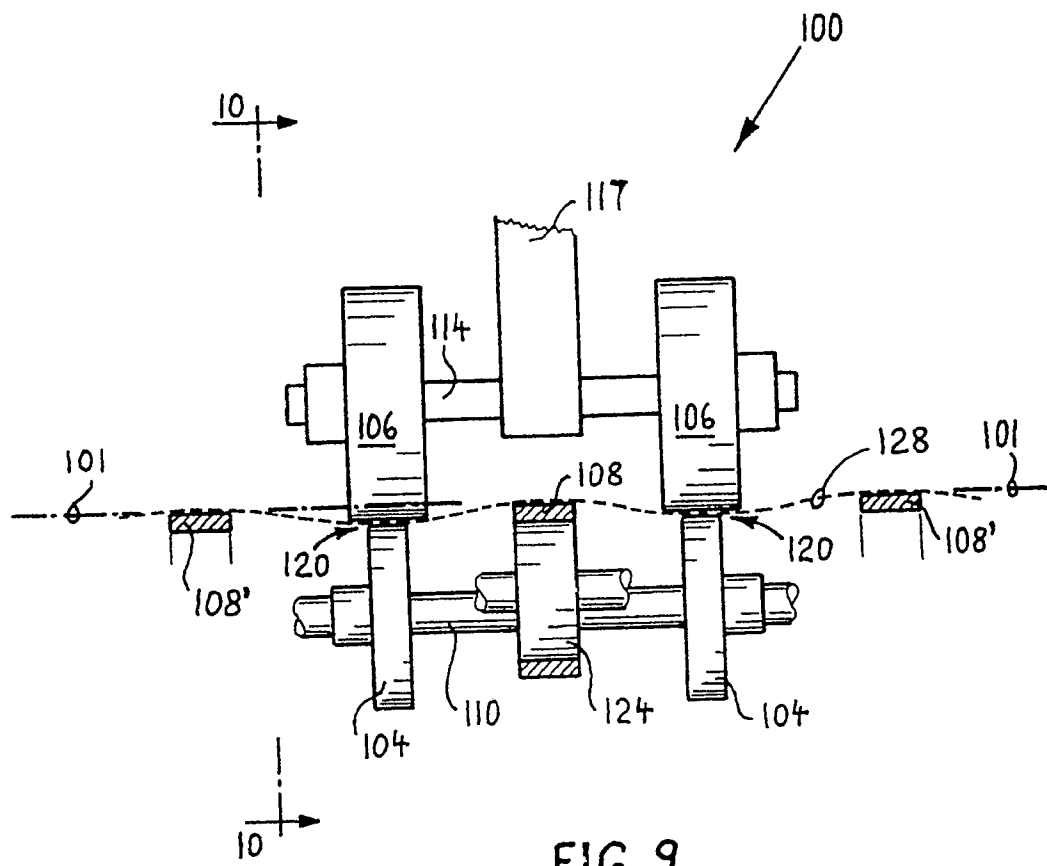


FIG. 8



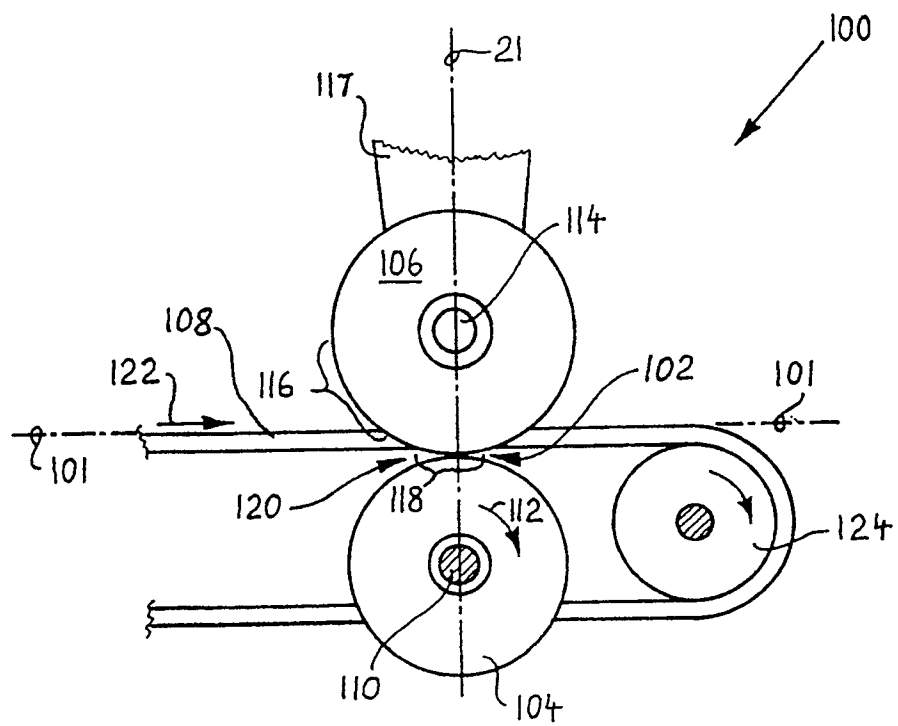


FIG.10



European Patent
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EUROPEAN SEARCH REPORT

Application Number

EP 91 30 4436

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	DE-A-3 508 981 (GLORY KOGYO)	1,7, 10-12	B65H3/04 B65H3/46
Y		5,9	
A	* page 18, line 19 - page 18, line 34; figures 10-12 *	4,8	

X	CA-A-1 127 193 (LONG)	1,7, 10-12	
A	* page 8, line 23 - page 9, line 12; figures 5,6 *	4,8	

Y	NL-A-6 900 533 (INGENIEURSBUREAU DE RIDDER N.V.) * page 6, line 14 - page 6, line 35; figure 4 *	5,9	

A	XEROX DISCLOSURE JOURNAL vol. 4, no. 1, February 1979, page 63; V.R.GREEN: 'sheet feeding method for machines with belt transport '	2-4	

A	PATENT ABSTRACTS OF JAPAN vol. 9, no. 149 (M-390)(1872) June 25, 1985 & JP-A-60 26 538 (CANON) February 9, 1985 * the whole document *	2-4	TECHNICAL FIELDS SEARCHED (Int. Cl.5)

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The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 30 AUGUST 1991	Examiner EVANS A.J.
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application I : document cited for other reasons & : member of the same patent family, corresponding document	

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